Dipole Measurements For the AØ Photoinjector

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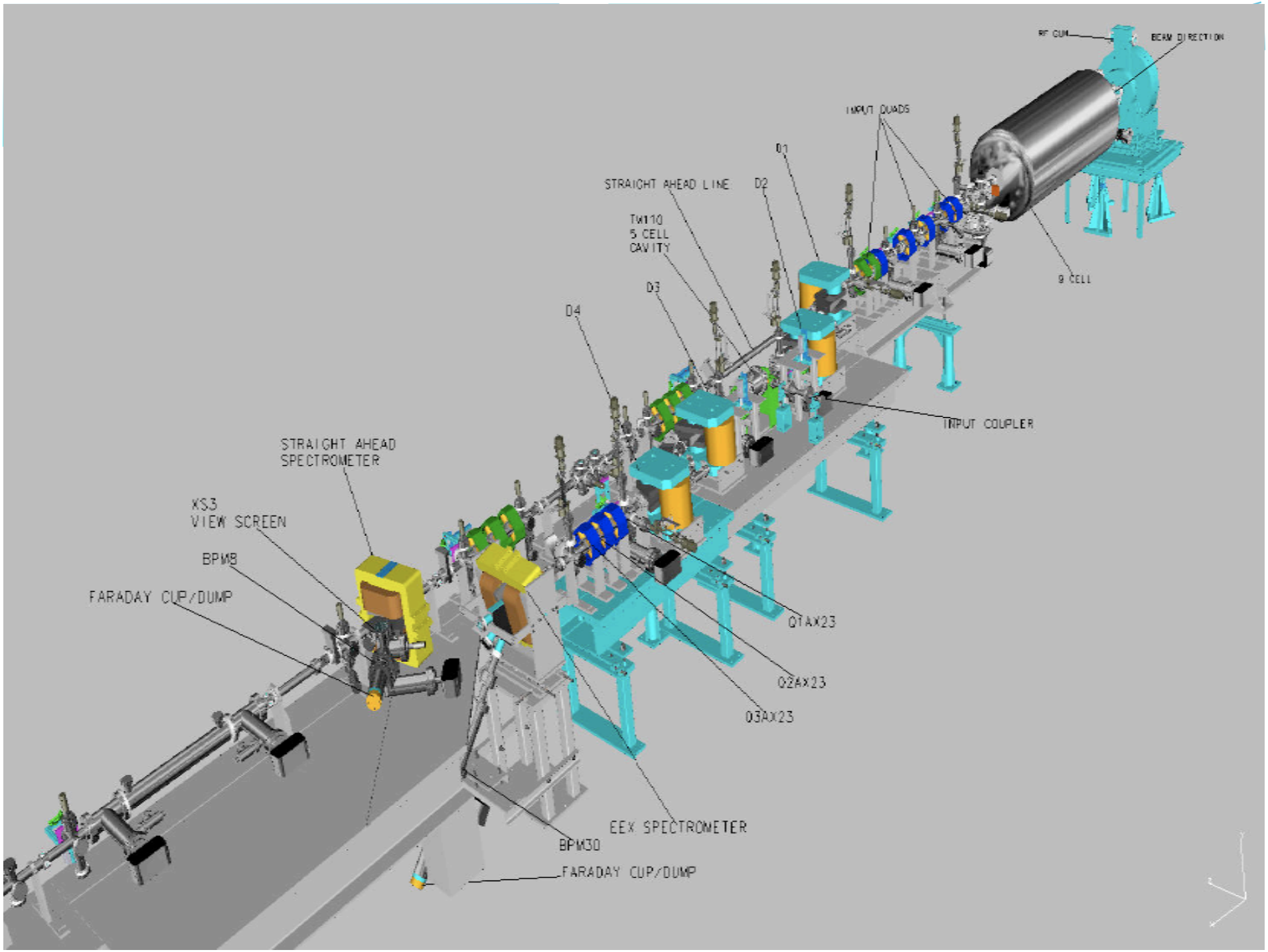
Outline

- AØ Photoinjector (Background)
- Function of dipole magnets
- About dogleg set-up
- “Get to the point what was your project about!! ” (Purpose)
- Learning the tricks of the trade (Small dipole measurements)
- Plots From dipole magnets
- Summary

A0 Photoinjector (Background)

- **Originally For the TeV Superconducting Linear Accelerator (TESLA) project, AØ served as the Test Facility for the project known as the TESLA Test Facility (TTF) now know as AØPI**
- **The AØ Photoinjector (AØPI) is a linear accelerator that accelerates electrons up to 16 MeV**
  - **Uses a photocathode to produce electrons**
- **Ultimate goal is accelerator research and development**
- **The AØPI now serves as a user facility for graduate and post graduate students.**
  - **Currently used for emittance exchange experiments**


RF GUN
BEAM DIRECTION
INPUT QUADS
D1
D2
STRAIGHT AHEAD LINE
TW110
5 CELL
CAVITY
D3
D4
9 CELL
INPUT COUPLER
STRAIGHT AHEAD
SPECTROMETER
XS3
VIEW SCREEN
BPM8
FARADAY CUP/DUMP
QTAX23
Q2AX23
Q3AX23
EEX SPECTROMETER
BPM30
FARADAY CUP/DUMP

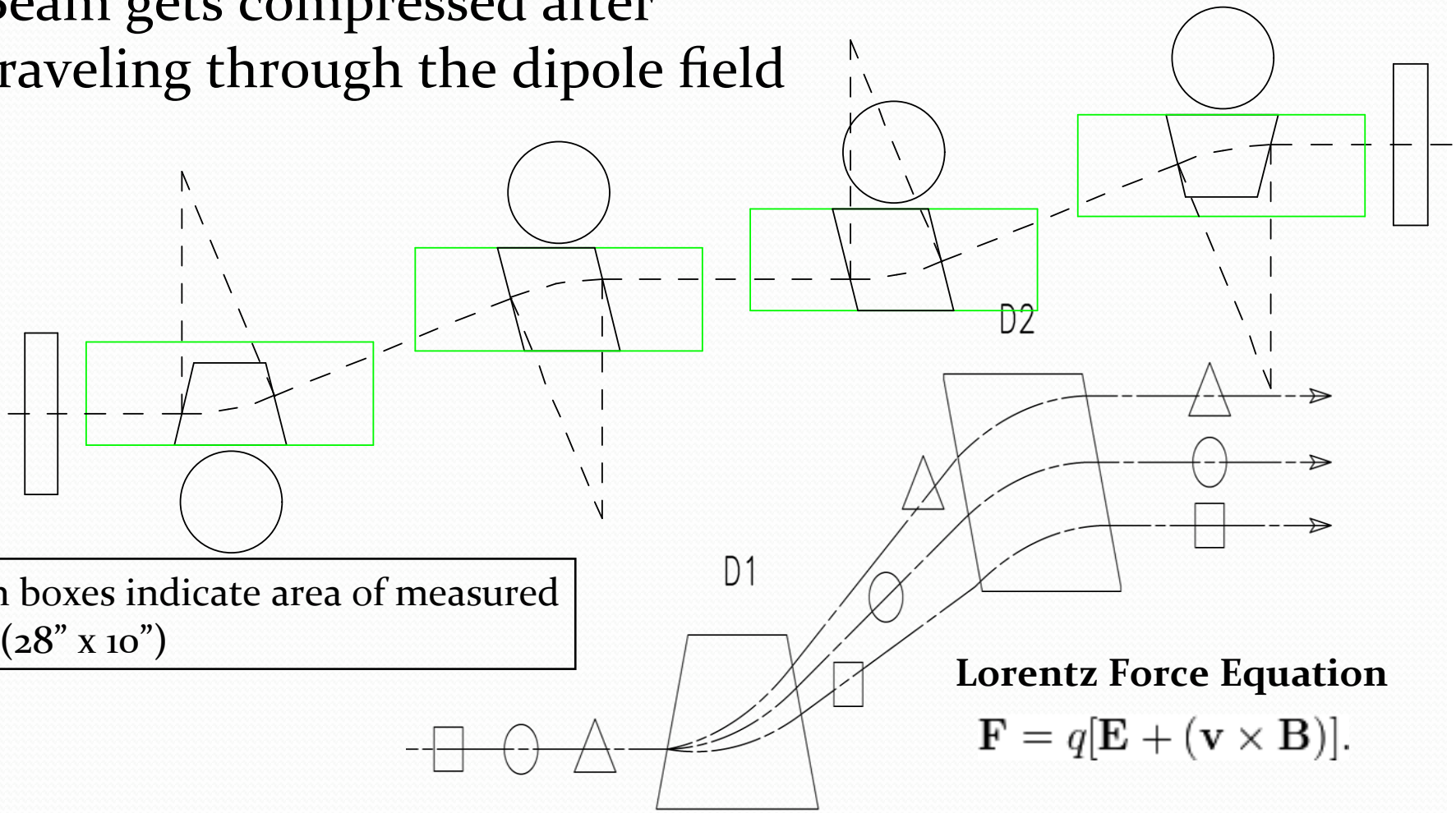
Function Of Dipole Magnets

- 4 dipole magnets are used in the photoinjector for dispersion and compression purposes
- Each bend beam at 22.5°
- Each of the dipoles operate @ 1.8A,
- 18 layers of coils wrapped longitudinally around steel 87 times this comes out to 1,566 turns
  - According to Ampere's Law

$$\oint_C \mathbf{B} \cdot \mathrm{d}\boldsymbol{\ell} = \mu_0 I_{\mathrm{enc}}$$

About Dog Leg Set-up

- Beam gets compressed after traveling through the dipole field

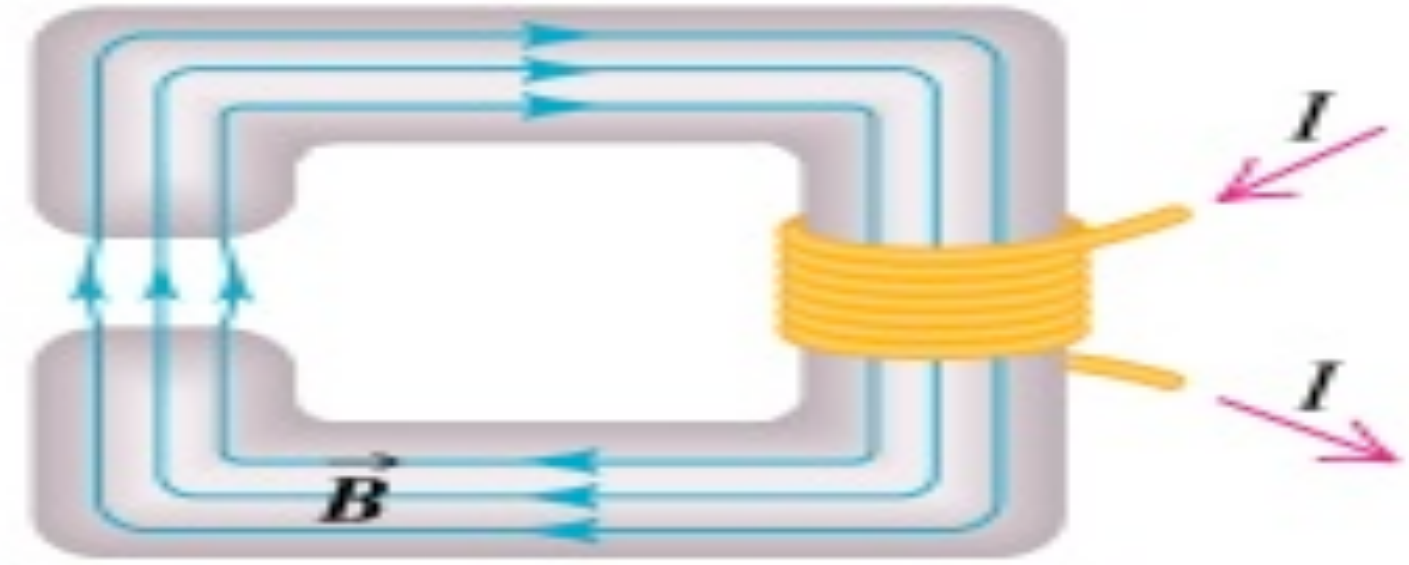


green boxes indicate area of measured field (28" x 10")

Lorentz Force Equation

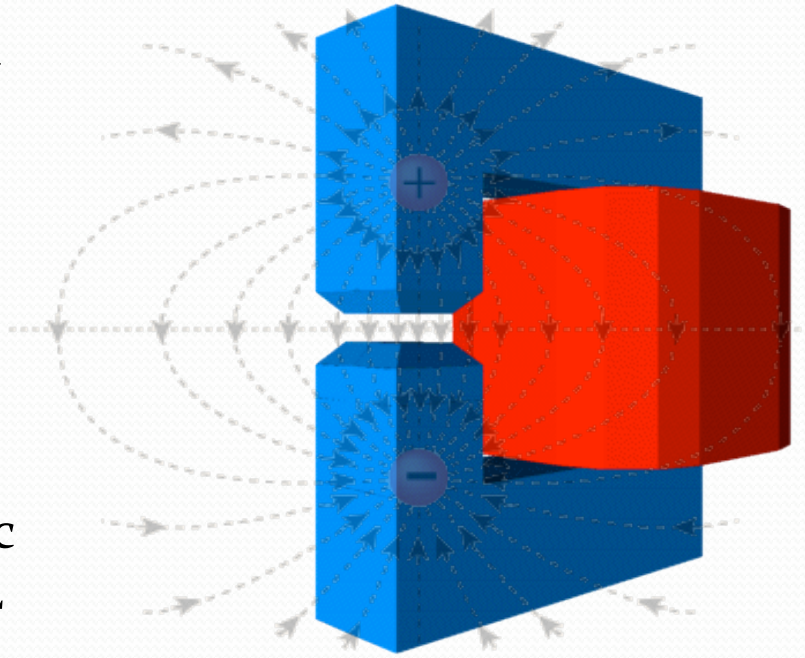
$$\mathbf{F} = q[\mathbf{E} + (\mathbf{v} \times \mathbf{B})].$$

C-Framed Magnets

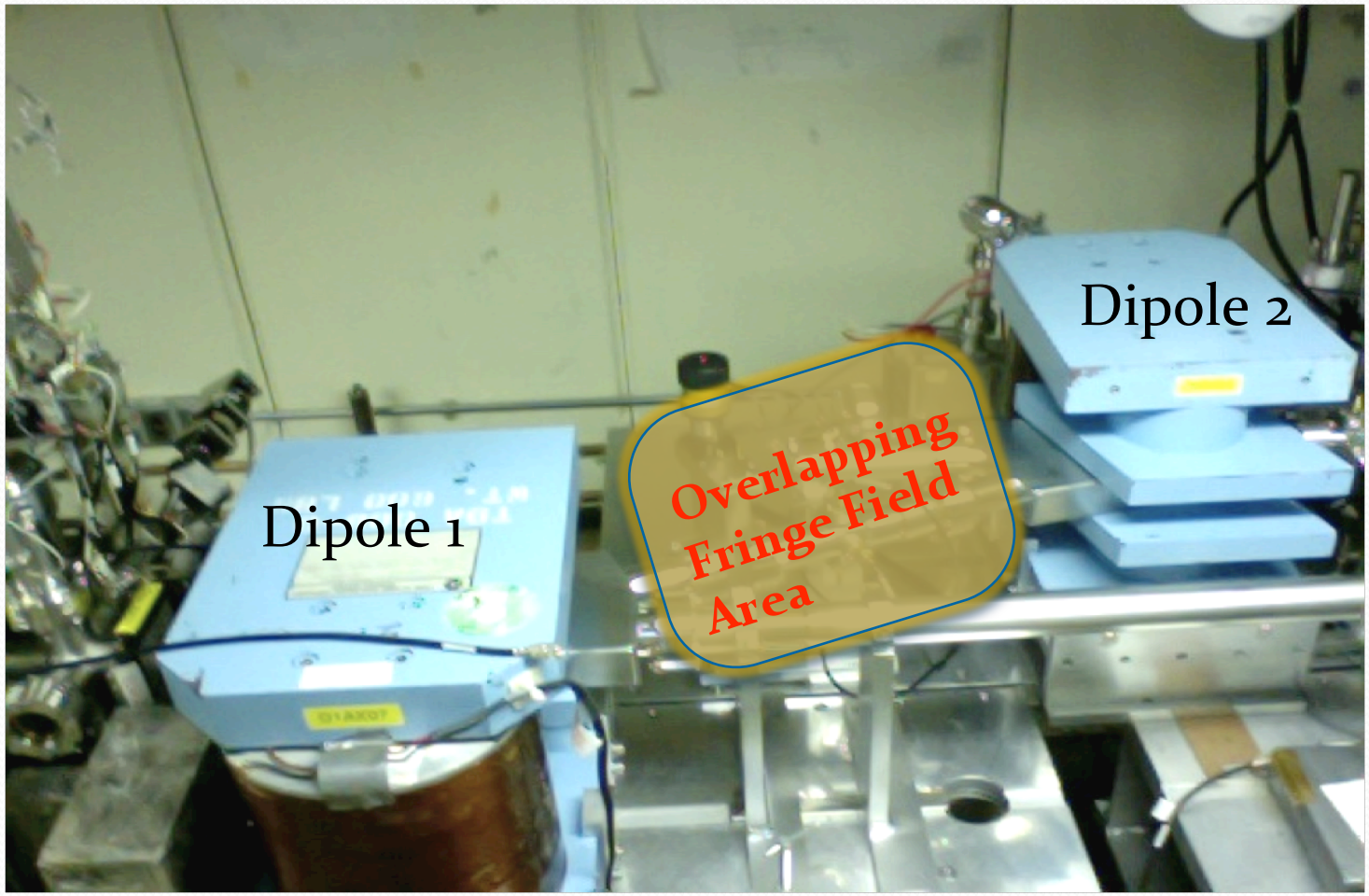


"Get to the point what was your project about!! " (Purpose)

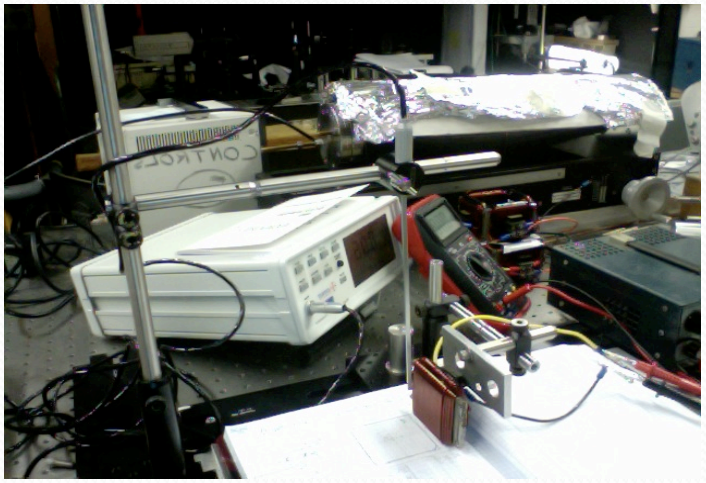
- Undesired interaction between the magnetic fringe fields of the 1st and 2nd dipole magnets in the photoinjector
- The dipoles are C-framed magnets
  - This design can produce excess magnetic field (fringe field)
- Fringe fields need to be measured
  - to help understand the problematic interaction between dipoles 1 and 2
- This is where I come in!!

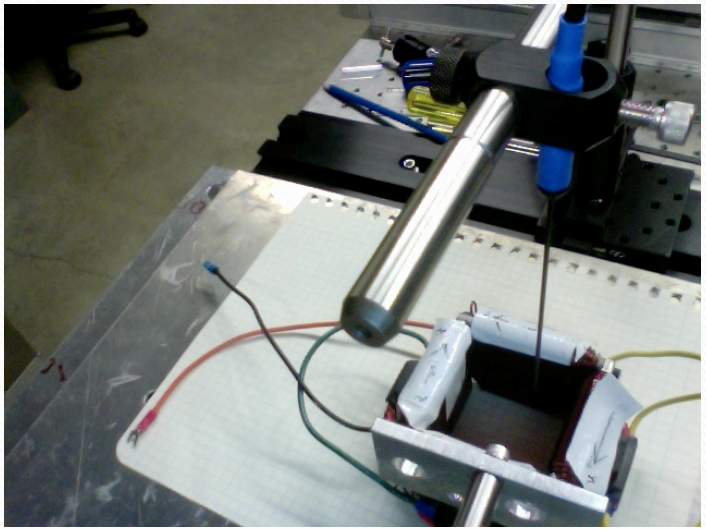


TDA Dipole Magnets 1 and 2



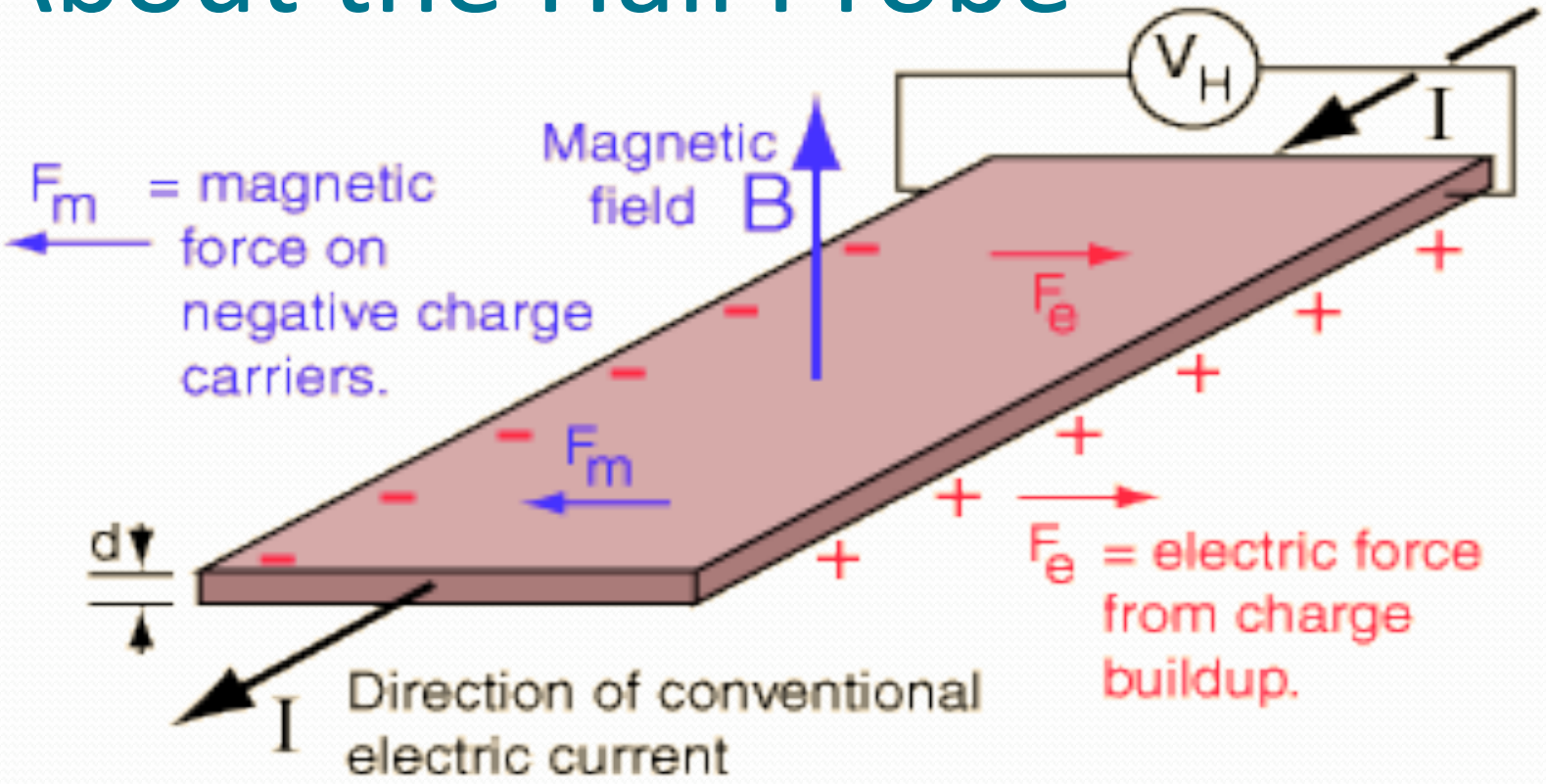
Learning the tricks of the trade (Small dipole measurements)





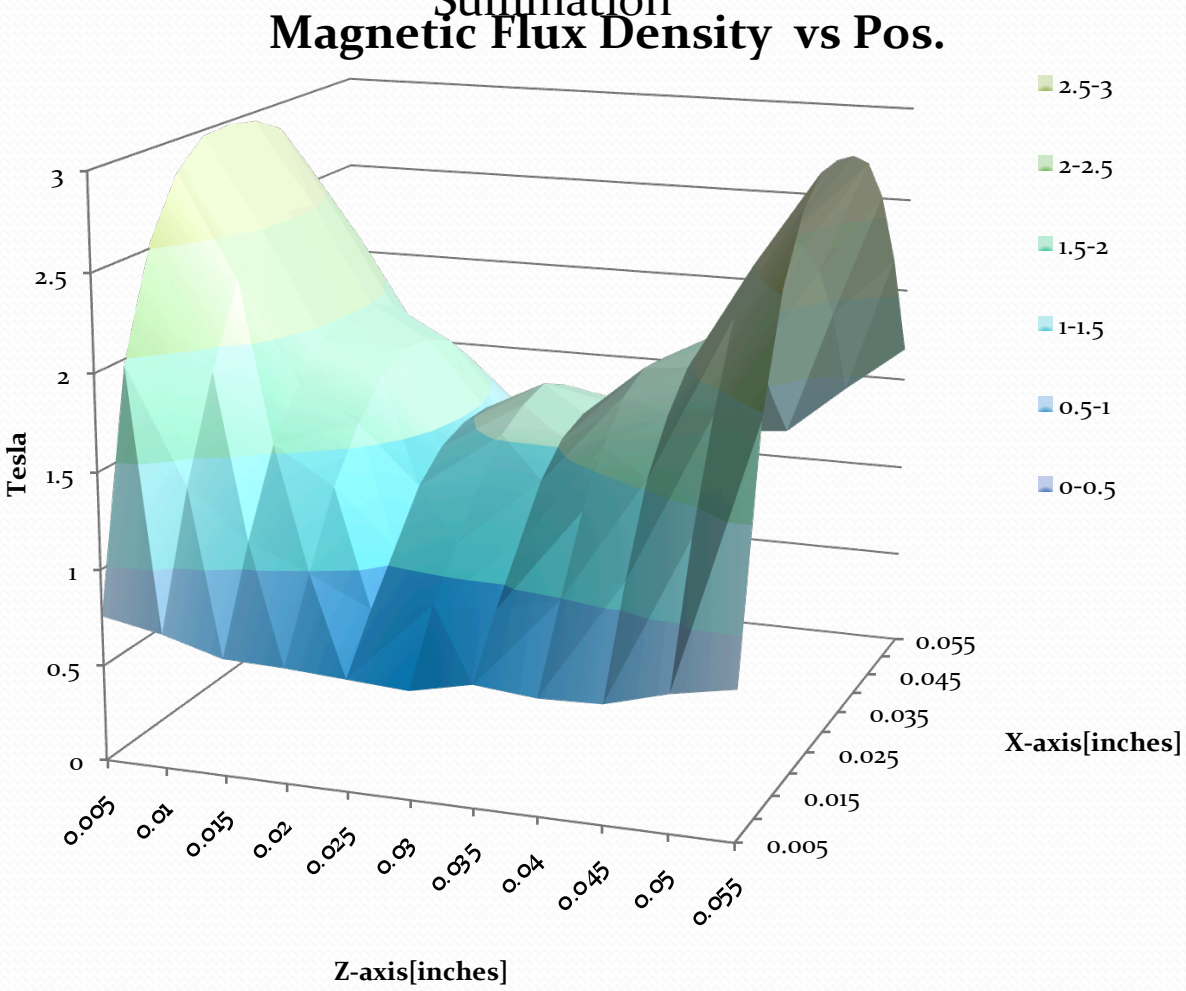
- Small scale measurements on corrector magnets
  - Rewired quadrupole magnets to have a dipole field
- Fabricated a mini magnet test stand to conduct my own measurements
- Studied flux line behavior

About the Hall Probe

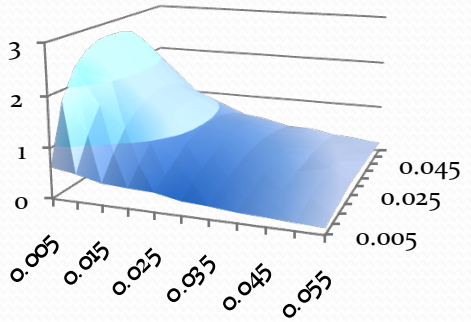


Plots From Dipole Small Measurements

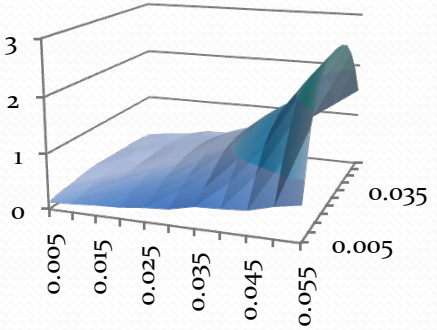
Summation



Left Pole

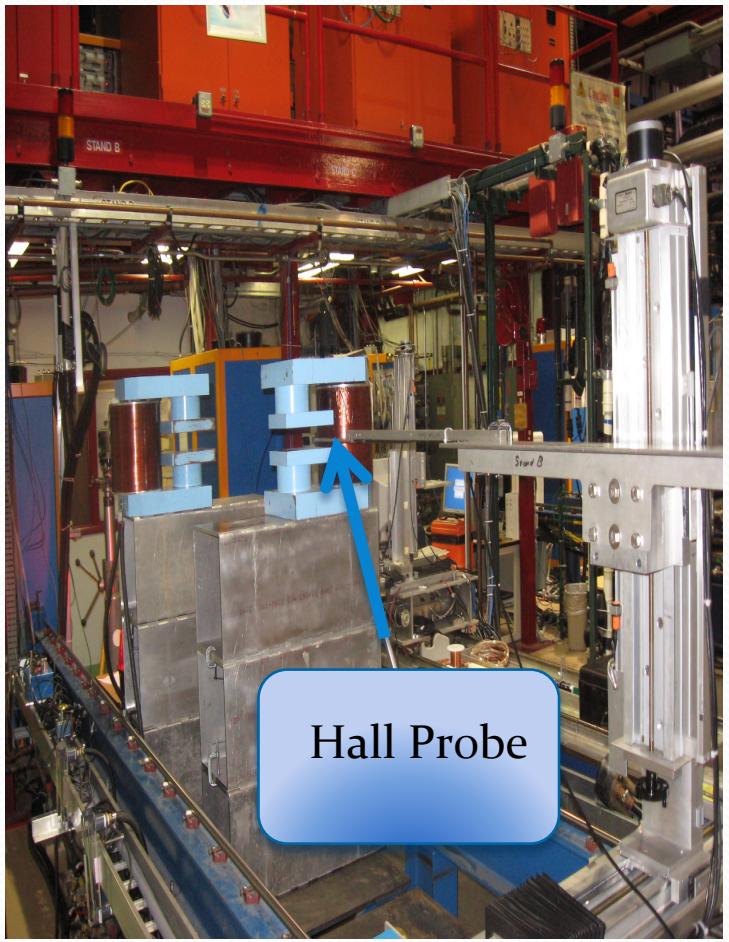


Right Pole



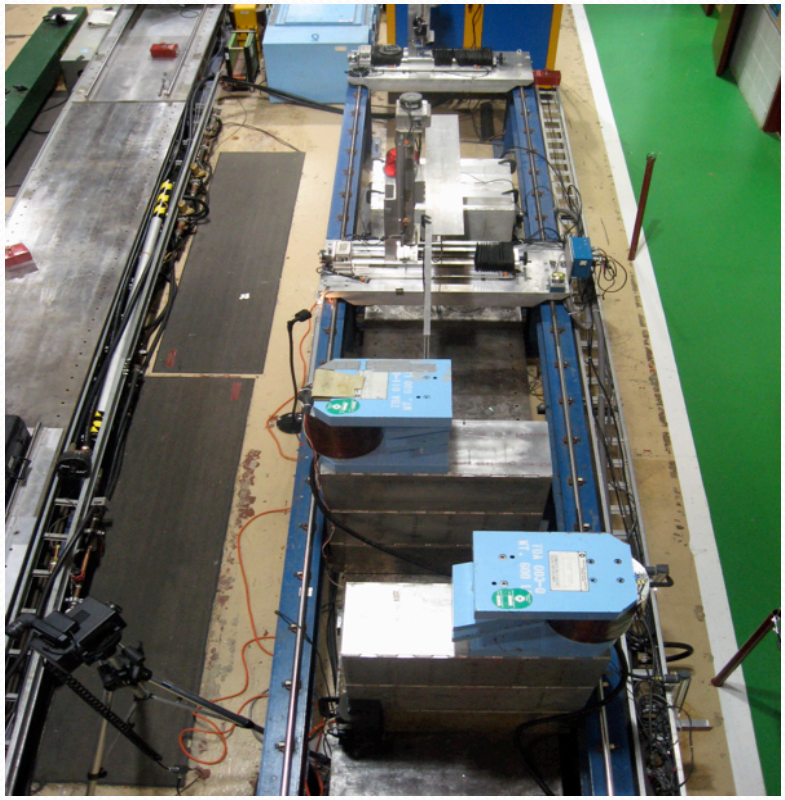
The Pre Game Preparations (Measurements)

- Measurements of large dipoles were performed at the Magnet Test Facility (MTF)
- Measured half inch increments over a 52" X 20" area
- Performed two sets of measurements
  - Each set was done twice, at 1.8A and 4.5A
- 1st set= 1 energized magnet @1.8A + repeat @4.5A
- 2nd set= 2 energized magnet @1.8A repeat @4.5A

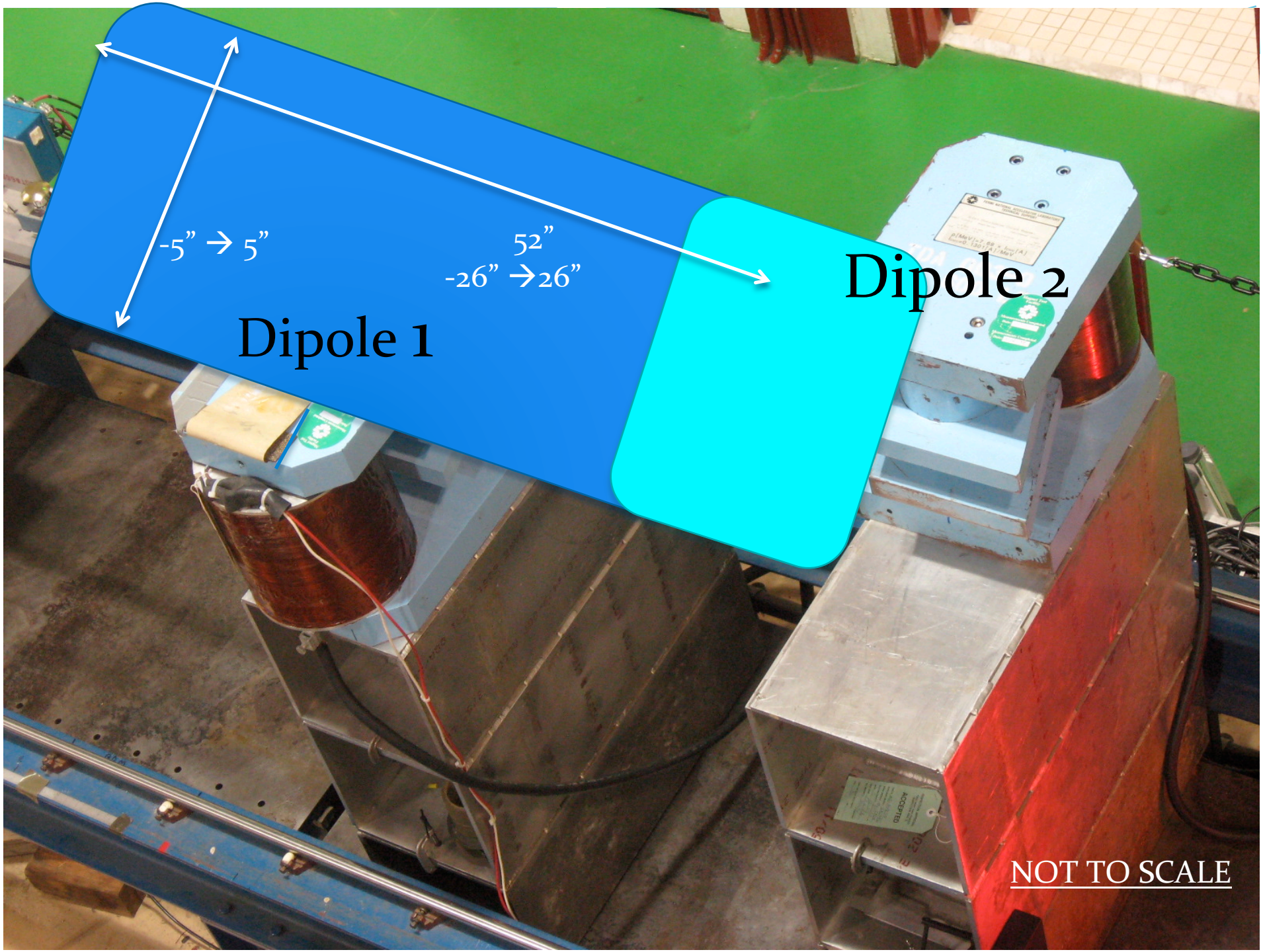


…continued

- Dipoles had to be aligned EXACTLY in the same way they are aligned in beam line

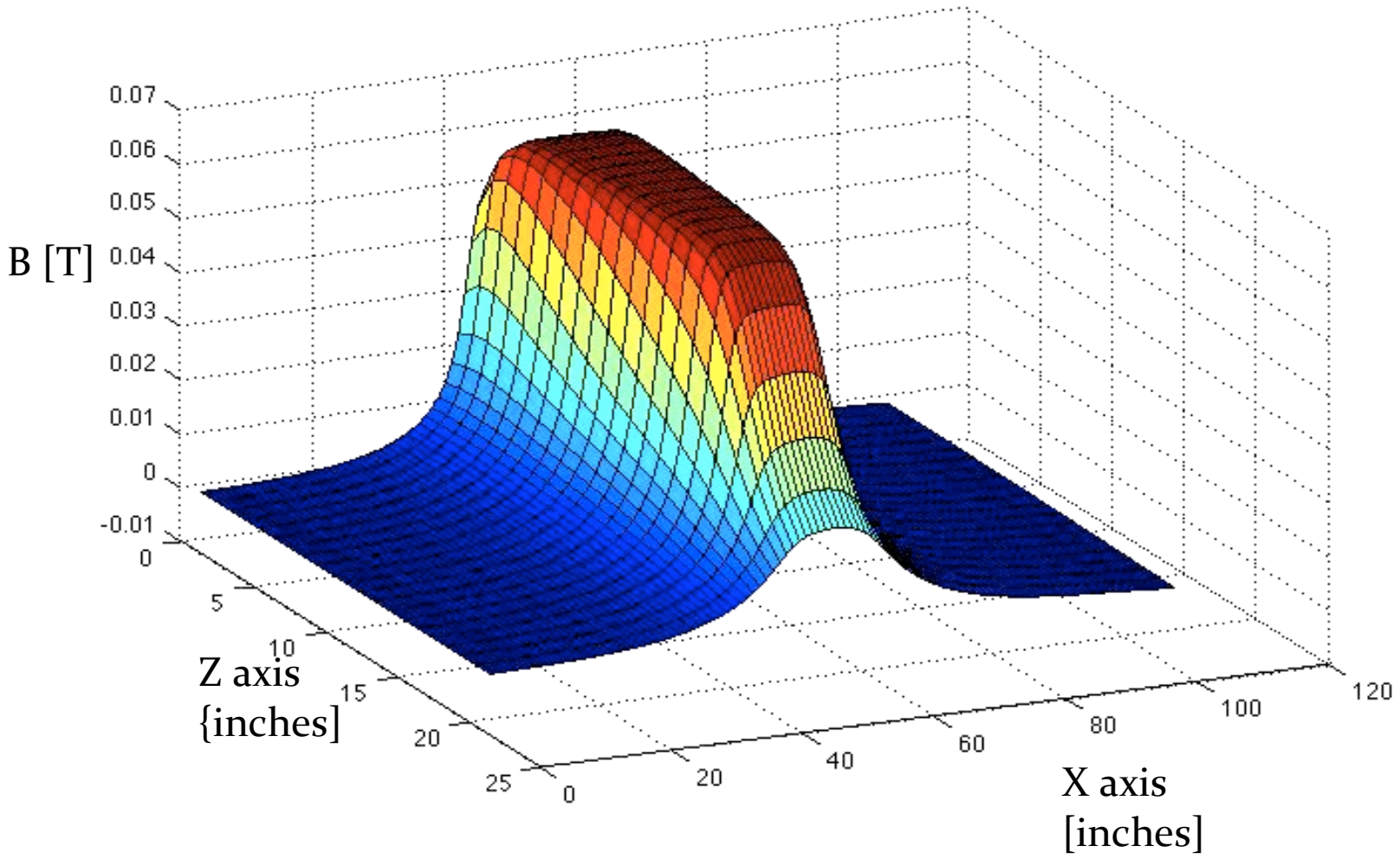


Goal of measurements is to create the same magnetic field produced in the beam line

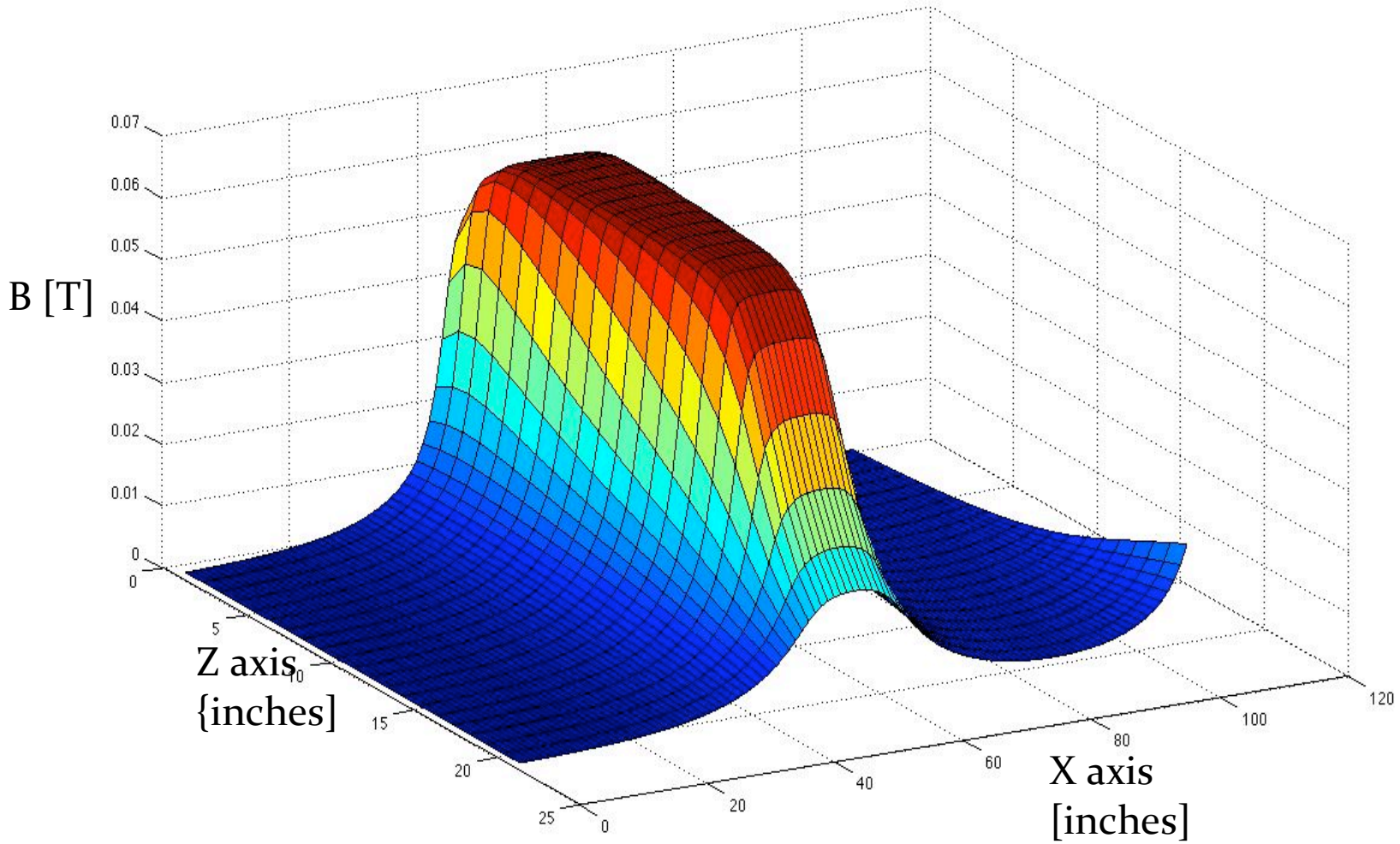

-5" → 5"
52"
-26" →26"
Dipole 1
Dipole 2
NOT TO SCALE

RESULTS

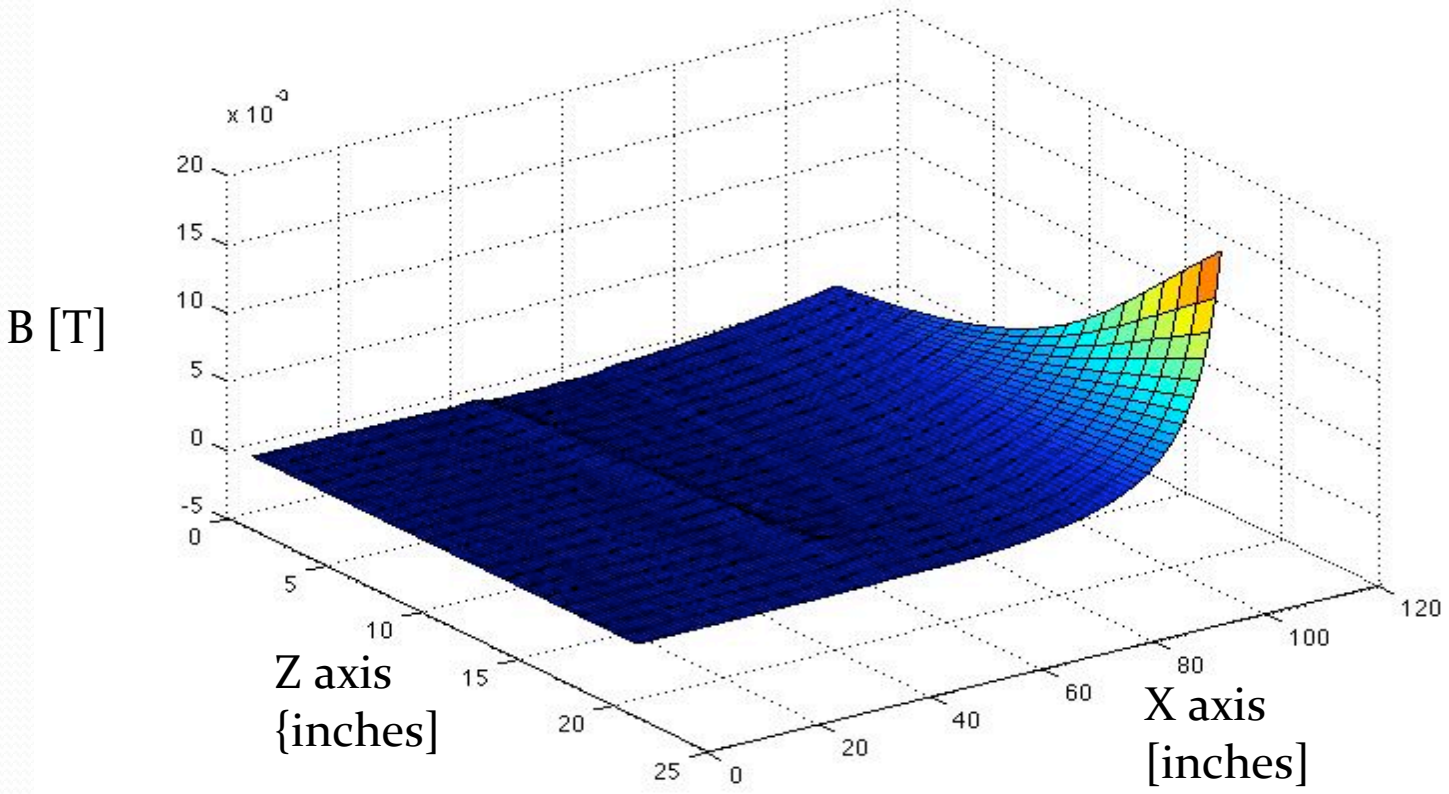
Dipole 1 Powered @1.8A



Dipole 1 & 2 Powered @1.8A

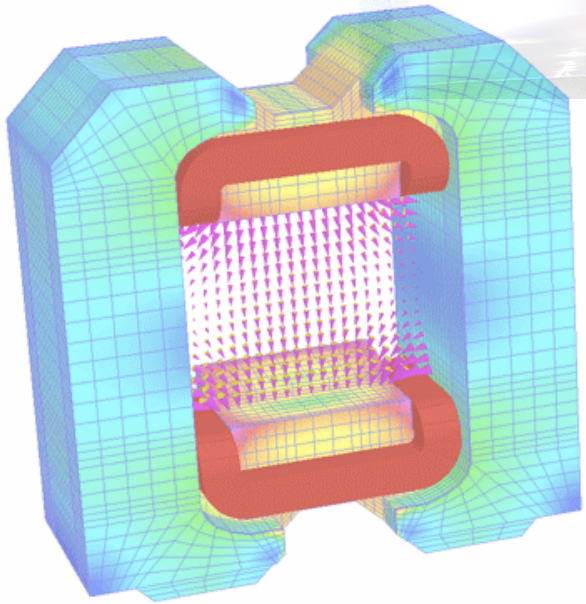


DIFFERENCE PLOT



Summary

- Measurements performed confirm that fringe field interactions between dipoles 1 and 2 exists
- Possible solution:
  - Utilize magnetic shielding
  - Invest in Box frame magnets



I'd Like to thank

- SIST Staff and Committee
  - Including; Dr. Davenport, Dianne Engram, Elmie Peoples, Dave Peterson,,
- AØ Group
- MTF Group
- Accelerator Division physicists
  - Including; Helen Edwards, Mike Church, Mike Syphers, Randy Thurmen-Keup, Michael Cooke, Amber Johson, Arden Warner, Chandra Bhat

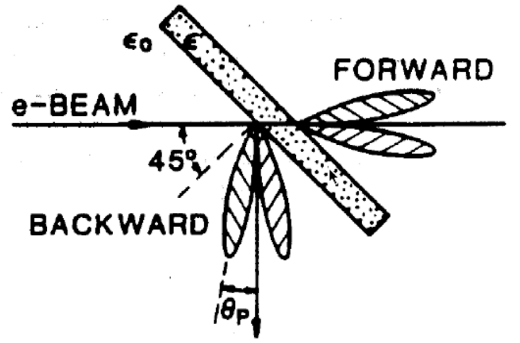
Extra slides

THE GREAT WAIT

- Crash Course in OTR (Optical transition radiation)
  - Worked At Pelletron
- Beam Optics 101
  - Hills equation
  - Thick lenses and Thin lenses
- Took advantage off The great tours that were available!

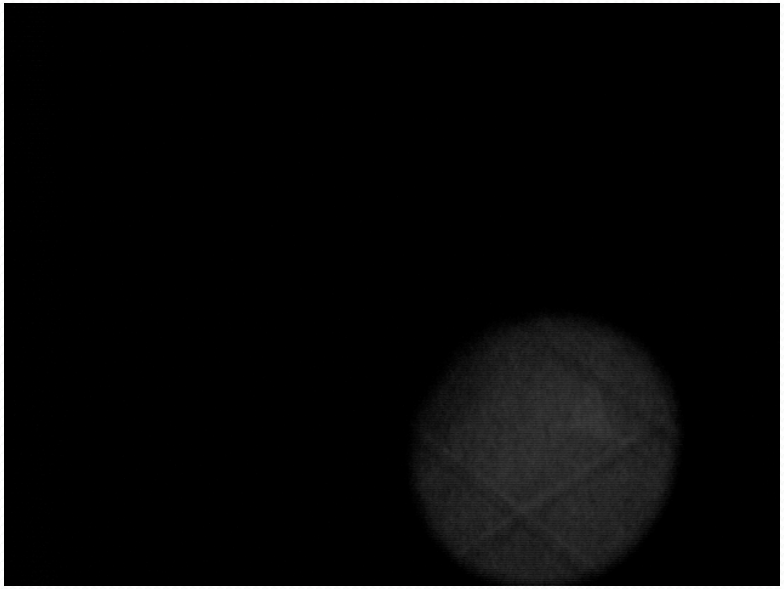
Opticle Transiition Radiation

- AT Pelletron OTR test were conducted to determine if thermal cathode needed to be replaced.
- An aluminum film placed at 45° reflects radiation in the visible spectrum (LIGHT)
- OTR shows light intensity and spatial information
  - Used also in Photoinjector to determine position of Beam

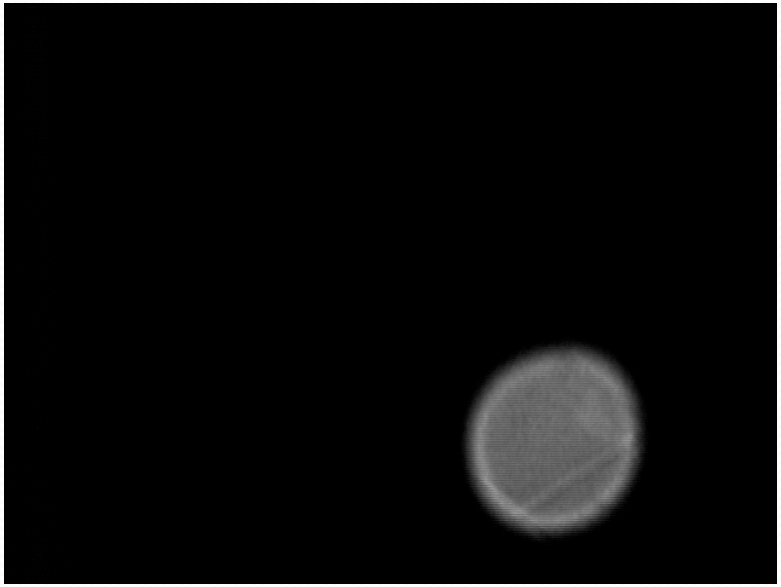


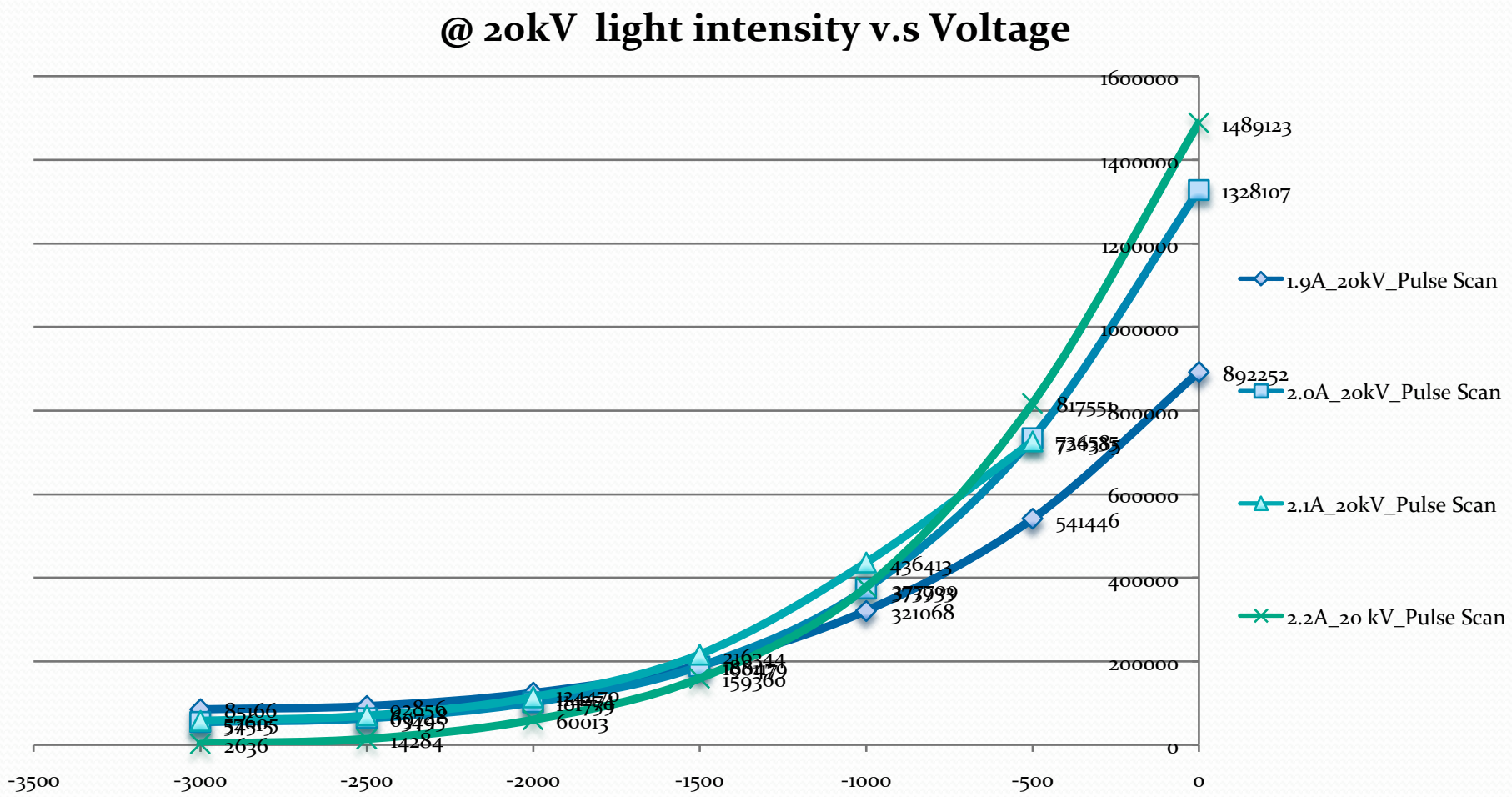
OTR PHOTOS

35KeV



20KeV




@ 20kV light intensity v.s Voltage
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
-3500
-3000
-2500
-2000
-1500
-1000
-500
0
1489123
1328107
892252
541446
321068
159300
60013
14284
2636
1.9A_20kV_Pulse Scan
2.0A_20kV_Pulse Scan
2.1A_20kV_Pulse Scan
2.2A_20 kV_Pulse Scan

Equation behind It all

- Model Beam position after thick lens
- Assume that only a dipole fields exists
- Neglect energy loss from cyclotron radiation

$$\begin{pmatrix} x \\ x' \\ y \\ y' \\ z' \\ \frac{\Delta p}{p} \end{pmatrix} = \begin{pmatrix} R_{11} & R_{12} & R_{13} & R_{14} & R_{15} & R_{16} \\ R_{21} & R_{22} & R_{23} & R_{24} & R_{25} & R_{26} \\ R_{31} & R_{32} & R_{33} & R_{34} & R_{35} & R_{36} \\ R_{41} & R_{42} & R_{43} & R_{44} & R_{45} & R_{46} \\ R_{51} & R_{52} & R_{53} & R_{54} & R_{55} & R_{56} \\ R_{61} & R_{62} & R_{63} & R_{64} & R_{65} & R_{66} \end{pmatrix} \begin{pmatrix} x_0 \\ x'_0 \\ y'_0 \\ y'_0 \\ z'_0 \\ \frac{\Delta p}{p} \end{pmatrix}$$